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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

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ENVIRONMENTAL SPECIFICATIONS FOR FIXED HEAD DISK STORAGE SYSTEMS IN NON-TACTICAL APPLICATIONS

by

Gordon P. Marques

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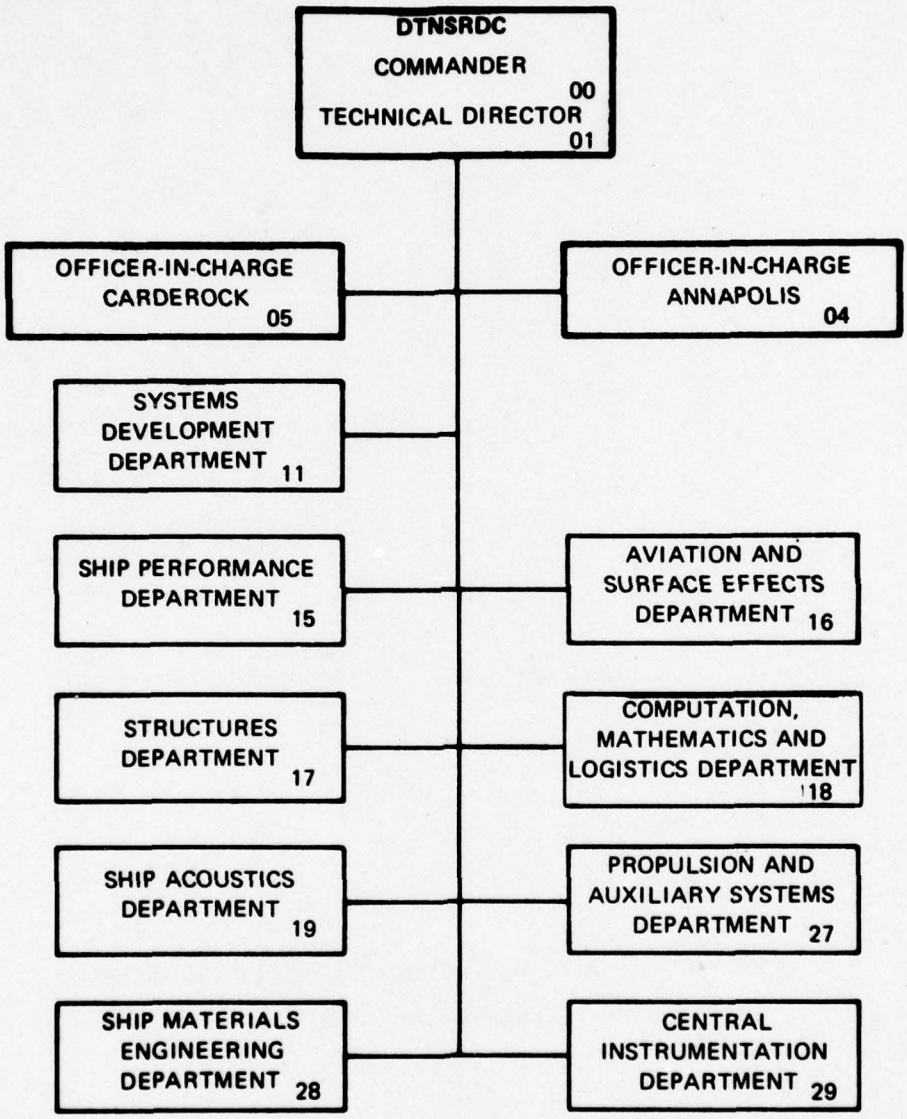

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The purpose of this study was to investigate and develop minimal environmental and electromagnetic interference testing requirements that would insure normal survivability aboard ship for a fixed head mass storage disk system. These environmental and electromagnetic interference specifications are intended for units that will be used only in non-tactical applications.

Minimal environmental and electromagnetic interference test requirements were developed. Two different manufacturers of commercially ruggedized fixed

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disk storage units lent the Navy their units for the purpose of evaluating the environmental and electromagnetic test requirements. These units were tested at a testing facility and the results are included in this report.

The test results indicate that these proposed environmental and electromagnetic interference test requirements can be satisfied but that not all commercially ruggedized fixed head disk storage units can satisfy them.

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ABSTRACT

The purpose of this study was to investigate and develop minimal environmental and electromagnetic interference testing requirements that would insure normal survivability aboard for a fixed head mass storage disk system. These environmental and electromagnetic interference specifications are intended for units that will be used only in non-tactical applications.

Minimal environmental and electromagnetic interference test requirements were developed. Two different manufacturers of commercially ruggedized fixed head disk storage units lent the Navy their units for the purpose of evaluating the environmental and electromagnetic test requirements. These units were tested at a testing facility and the results are included in this report.

The test results indicate that these proposed environmental and electromagnetic interference test requirements can be satisfied by at least one commercially ruggedized fixed head disk storage unit.

ADMINISTRATIVE INFORMATION

This study was produced by the Computer Science and Information Systems Division, Computation, Mathematics and Logistics Department, David W. Taylor Naval Ship Research and Development Center under the auspices of the Center's Shipboard Logistics Data Processing Systems project. This project is funded by the Research and Technology Division, Naval Supply Systems Command (SUP 0431C), Task Area TF 53531001, Project F53531, Element 62760, Work Unit Numbers 1824-001 and 1824-003.

INTRODUCTION

The Navy is looking for reliable, low cost mass storage devices for non-tactical (logistics) application. It is reasonable to first consider buying off-the-shelf commercially ruggedized as opposed to militarily ruggedized equipment. If commercially ruggedized equipment can be purchased and shown to be reliable aboard ship in a non-tactical environment, the cost savings to the Navy can be considerable. Commercially ruggedized equipment is approximately one third the cost of militarily ruggedized equipment.

The objective of the Shipboard Logistics Data Processing project, funded by the Naval Supply Systems Command, is to develop, integrate, test and evaluate components of shipboard logistics data processing systems. This project is to acquire and/or develop components for storage, communications and transmission of logistics data; conduct environmental tests of equipment under laboratory conditions; establish software interfaces; integrate prototypes into shipboard data processing systems; and conduct shipboard environmental tests under at-sea or dockside conditions.

Under the present system of electronic hardware acquisition, all equipment which is designated for Navy shipboard use must be subjected to the analysis and testing specifications of MIL-E-16400G.[1*] A review of MIL-E-16400G in relation to measured shipboard data indicates that savings in time and money can be gained by reducing environmental analysis and requirements testing. However, it should be emphasized that the reductions of MIL-E-16400G requirements cannot apply to critical equipment; critical equipment being that without which the ship cannot operate or perform its mission. The reductions of MIL-E-16400G would include only those tests and analysis requirements pertaining to abnormal conditions, that is, conditions which very rarely occur aboard an operational Navy ship. Examples of such conditions would be a nearby underwater blast, a nuclear air blast, and simultaneous high temperature and high relative humidity.

SPECIFICATION DESIGN

Specifications for environmental testing of commercially ruggedized fixed head disk storage units were drawn from two sources: the Telecommunications Equipment Low Cost Acquisition Method (TELCAM) study and the Data Entry Aboard Ship (DEAS) study, as discussed in the following two paragraphs.

Suggestions for eliminations of or modifications to the test and analysis requirements of MIL-E-16400G of the sort mentioned above were made by the Engineering Sciences Department, Naval Electronics Laboratory Center, under the auspices of the Center's Low Cost Electronics/TELCAM project. Low Cost Electronics is an acquisition R&D project which is

*A complete listing of references is given on page 17.

studying and making recommendations on ways to obtain better electronic equipment at a lower total cost. TELCAM addresses the use of existing commercial and military equipments in new military applications. Appendix A of the Project Manager's Guide Low Cost Electronics Project[2] is the TELCAM Environmental Study. This environmental study identifies three important environmental conditions that exist on all ships: temperature, relative humidity, and vibration. The TELCAM temperature/relative humidity and vibrational envelopes were chosen as specifications in the Shipboard Logistics Data Processing test for their respective areas.

An exception to the relaxation of requirements for abnormal conditions is the following type of shock not addressed by MIL-E-16400G. This shock is created by the muzzle blast from the ship's own guns impinging on external bulkheads. The severity of this type of shock depends on the distance from the gun muzzle to a bulkhead and the distance from this bulkhead to the equipment mounting. Past attempts to analytically qualify equipment to this type of shock have met with little or no success. Since the TELCAM environmental study does not specify shock criteria, a certain level of confidence of normal operation of the disk storage unit under this type of shock could be obtained by incorporating the shock specifications of the DEAS environmental requirements. These specifications are included in a study made by SAI Comsystems Corporation for the David W. Taylor Naval Ship Research and Development Center (DTNSRDC).[3] This study was to define the operating characteristics and specifications for a logistics and administrative data entry system that would be commercially ruggedized as opposed to militarily ruggedized.

Along with the shock specifications previously mentioned, the inclination, electromagnetic compatibility (EMI), electrical power, altitude, package drop, and package vibration specifications of DEAS were incorporated into the proposed environmental specifications for the present disk storage unit. The specifications derived from the TELCAM and DEAS studies will be found in the Appendix.

VERIFICATION

Two representative fixed head disk storage units were subjected to the environmental and EMI/RFI testing requirements at a commercial testing facility. This facility provided a test plan,[4] test facilities, test data, and test reports[5,6] on both units. Results of the testing of the representative fixed head disk storage units are listed for each test specified in the Appendix.

CONCLUSIONS

The proposed environmental and EMI/EMC specifications can be satisfied by a commercially ruggedized fixed head disk storage unit. The deviations from the specifications by test item A can be corrected by modifications to the unit. These modifications are minor and this manufacturer expects they will be made in the near future. One of the modifications to this unit is a new electromagnetic interference filter on the input of the power line cord. This modification will be sufficient to satisfy the electromagnetic interference requirements of MIL-STD-461A, test CE03. The broad and narrow band requirements of MIL-STD-461A, test RE02 can be satisfied by shielding the signal cable between the disk storage unit and the controller. It is unlikely the head crash that occurred to this item while undergoing the X-axis variable frequency vibration test can be attributed to the low level vibration that it was experiencing. Subsequent inspection by the manufacturer indicated that a mechanical failure of the head to retract to the flying position caused this catastrophic failure. Another factor indicating that the mechanical failure was not related to the vibrational environment is the fact that the item was repaired and retested through a complete vibration test and satisfied all requirements. This item also satisfied the requirements of the shock specifications immediately after satisfying the vibrational test requirements.

Testing of test item B was terminated after several attempts to qualify this item to the vibration test requirements. Vibration testing was done on two of this manufacturer's units and neither was able to satisfy the requirements. The vibration test requirements constituted the major problems with test item B. The difference in test results for Items A and B indicates that some fixed head disk systems are more susceptible to

vibration than others. Test item B also failed to meet the temperature/relative humidity test requirements and several of the EMI test requirements. This item could satisfy the temperature/relative humidity test requirements if a helium gas bottle were added to the unit, but the manufacturer chose not to include this option in the test item. Shielding of the appropriate cables could help this item to satisfy the EMI test requirements. Since testing of this item was terminated in the vibration testing and the item was at that time inoperable, no results were obtained for the shock and box drop tests.

The test specifications used here were not developed to test equipment for survivability under abnormal shipboard environments, but to provide confidence that the equipment will operate in the usual environments. Since any shipboard mounted equipment is constantly exposed to vibration and temperature/relative humidity environments during at-sea operations, both the temperature/relative humidity and the vibration tests developed by TELCAM should be considered as minimum requirements to determine equipment survivability under these conditions. The DEAS shock requirements were added to give additional confidence in the survivability of the fixed head disk systems in limited abnormal conditions. Whether or not other factors concerning noise, EMI, inclination, safety, and electrical power must be included in a particular test specification package will depend on the shipboard environmental constraints (noise level, location, energy source, etc.) to be met. Similarly, shipping conditions will determine the necessity of including shipping vibration and box drop tests.

The representative test units were subjected to these tests to determine whether a commercially ruggedized fixed head disk unit could meet any or all of these test requirements. The tests indicated that at least one fixed head disk unit can meet the environmental requirements and at least one cannot.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
1. Safety Ground - The safety ground of these test items will be inspected and shall conform to paragraph 3.10.11.2 and 3.4.8.4.1 of MIL-E-16400G.[1]	Test item A was inspected and conformed to paragraphs 3.10.11.2 and 3.4.8.4.1 of MIL-E-16400G.[1] Maximum resistance from enclosure to safety ground on power plug was 0.08 ohms.	Test item B was inspected and initially the resistance from the disk enclosure to the safety ground pin on the power plug was 0.8 ohm. However, ground lug on the disk was found to be loose. The lug was tightened and the disk enclosure to safety ground pin resistance dropped to a maximum of 0.1 ohm. The resistance from the power supply enclosure to the safety ground pin on the power plug was 0.25 ohm. Inspection showed that the sheet metal screw on the inboard side of connector J4A (power receptacle) did not electrically connect through the anodized coating on the chassis to form a good ground.
2. Leakage Current - The leakage current of these test items will conform to paragraph 3.10.11.6 of MIL-E-16400G.[1]	Test item A conformed to paragraph 3.10.11.6 of MIL-E-16400G.[1] Maximum leakage current was 0.61 ma.	Test item B conformed to paragraph 3.10.11.6 of MIL-E-16400G.[1] Maximum leakage current was 0.55 ma.
3. Electrical Power - All the test items will require only single phase, 60 Hz, 115VAC (RMS) input power. Power requirements shall not be greater than 1725VA (15 amp) circuit. The test items will be inspected for error-free operation at any supply voltage within ± 7 percent of nominal. All components of these test items shall be capable of enduring steady state power line frequencies between 57 and 63 Hz and shall provide error-free operation no later than 10 seconds after frequency is returned to within a 59 to 61 Hz range. The test items will be subjected to transient voltage tests (paragraph 4.8.5.2 and 4.8.5.2.2) only of MIL-E-16400G[1] and be capable of error-free operation following the transient. The test	Test item A conformed to electrical power requirements. Power consumption was 955 VA during startup and 270 VA at constant speed. Test item A was subjected to all electrical power test without showing any discrepancies.	Test item B conformed to electrical power requirements. Power consumption was 690 VA during startup and 202 VA at constant speed. Test item B was subjected to all electrical power tests without showing any discrepancies.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
3. Electrical Power - (Continued) items will be subjected to the transient frequency tests (paragraph 4.8.5.3) of MIL-E-16400G.[1] The test item need not provide error-free operation until 10 seconds after frequency has returned to within a 59 to 61 Hz range. The test items will be subjected to power interruption tests (paragraph 4.8.5.5) of MIL-E-16400G. 4. Electromagnetic Compatibility - The test items will be subjected to the following test methods of MIL-STD-461A[7] notice 3: CE01 Conducted Emission, Power Leads 30 Hz - 20 kHz CE03 Conducted Emission, Electric Field 14 kHz-1gHz RE02 Radiated Emission, Electric Field 14 kHz-1gHz and satisfy the requirements of these tests. In addition the test item will be subjected to the following test methods of MIL-STD-461A notice 3 for representative ship installation: CE02 Conducted Emissions, Power Leads 30Hz-20kHz CE04 Conducted Emissions, Control and Signal Leads 20kHz-50mHz CS01 Conducted Susceptibility, Power Leads 40kHa-400mHz RE01 Radiated Emission, Magnetic Field 30Hz-30kHz RS02 Radiated Susceptibility, Magnetic Induction Fields, Case and Cable 30Hz-30kHz RS03 Radiated Susceptibility, Electric Field 14kHz-10gHz MIL-STD-461A[7] test methods CE02, CE04, CS01, RE01, RS02 and RS03 need not be met but exceptions to limits are to be documented and reported.	Test item A was subjected to all electromagnetic compatibility testing and conformed to the limits of emission levels with the following exceptions: Peak dB Above Specification & Accompanying Frequency CE03 NARROWBAND — 115 VAC High — 4dB @ 5.5 mHz NARROWBAND — 115 VAC Return — 4dB @ 5.5 mHz NARROWBAND — 115 VAC Return — 13dB @ 16.2 mHz CE04 BROADBAND — Input Cable — 23dB @ 2.5 mHz BROADBAND — Input Cable — 8dB @ 8.1 mHz BROADBAND — Input Cable — 3dB @ 13.5 mHz BROADBAND — Input Cable — 3dB @ 23.5 mHz NARROWBAND — Input Cable — 30dB @ 5.3 mHz NARROWBAND — Input Cable — 20dB @ 11.0 mHz NARROWBAND — Input Cable — 30dB @ 16.0 mHz NARROWBAND — Input Cable — 23dB @ 21.9 mHz NARROWBAND — Input Cable — 21dB @ 27.0 mHz NARROWBAND — Input Cable — 16dB @ 32.5 mHz NARROWBAND — Input Cable — 4dB @ 37.0 mHz RE01 — Top Rear Corner — 4.5dB @ 45 Hz RE01 — Top Rear Corner — 8dB @ 135 Hz RE01 — Top Rear Corner — 0.5dB @ 1.44 kHz RE02 — Broadband — 7dB @ 100 mHz RE02 — Narrowband — 33dB @ 16.5 mHz	Test item B was subjected to all electromagnetic compatibility testing and conformed to the limits of the emission levels with the following exceptions: Peak dB Above Specification and Accompanying Frequency CE03 BROADBAND — DISK FILE — 14dB @ 1.32 mHz 115 VAC HIGH DISK FILE 115 VAC RETURN — 14dB @ 1.3 mHz POWER SUPPLY 115 VAC HIGH — 29dB @ 1.33 mHz POWER SUPPLY 115 VAC RETURN — 28dB @ 1.33 mHz NARROWBAND — POWER SUPPLY 115 VAC HIGH — 2dB @ 0.955mHz 6dB @ 1.17 mHz 11dB @ 1.31 mHz 2dB @ 2.23 mHz POWER SUPPLY 115 VAC RETURN — 10dB @ 1.32 mHz 17dB @ 2.24 mHz CE04 BROADBAND — SIGNAL CABLE — 44dB @ 1.3 mHz 6dB @ 15.2 mHz 5dB @ 19.6 mHz 8dB @ 24.2 mHz

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
4. Electromagnetic Compatibility - (Continued)		CE04 NARROWBAND SIGNAL CABLE 3dB @ 0.959 mHz 25dB @ 2.23 mHz 36dB @ 4.4 mHz 27dB @ 6.45 mHz 15dB @ 8.65 mHz 15dB @ 11.0 mHz 14dB @ 13.1 mHz 11dB @ 17.4 mHz 12dB @ 19.7 mHz 15dB @ 22.0 mHz 17dB @ 39.0 mHz RE02 NARROWBAND SIGNAL CABLE 40dB @ 4.4 mHz 28dB @ 8.62 mHz 22dB @ 11.0 mHz 34dB @ 64.0 mHz 32dB @ 43.0 mHz
5. Temperature - Humidity Test - The test items will be subjected to a temperature-humidity profile (Figure 1). The test is conducted by making five complete cycles around the trapezoid (Figure 1), starting and finishing at 95°F ± 2°F and 95 percent RH. Each test condition is maintained for 5 hours with 1 hour allowed for the transition between points, thereby making each cycle 24 hours. The test items will be checked for error-free operation during each stabilized environmental condition.	Test item A was subjected to the temperature-humidity test and no discrepancies were noted during the testing.	Test item B was subjected to the temperature-humidity test and numerous errors were noted at 122°F and 65% RH. The temperature was dropped to 104°F and 65% RH and the test item operated satisfactorily.
6. Altitude - The test items, while packaged for shipment, will be subjected to an altitude of 12,200 meters for 60 minutes. The test items will then be returned to normal conditions of altitude and unpacked. The test items will be inspected for damage and operated at normal power while being checked for error-free operation.	Test item A was subjected to the altitude test and no discrepancies were noted during testing.	Test item B was subjected to the altitude test and no discrepancies were noted during testing.

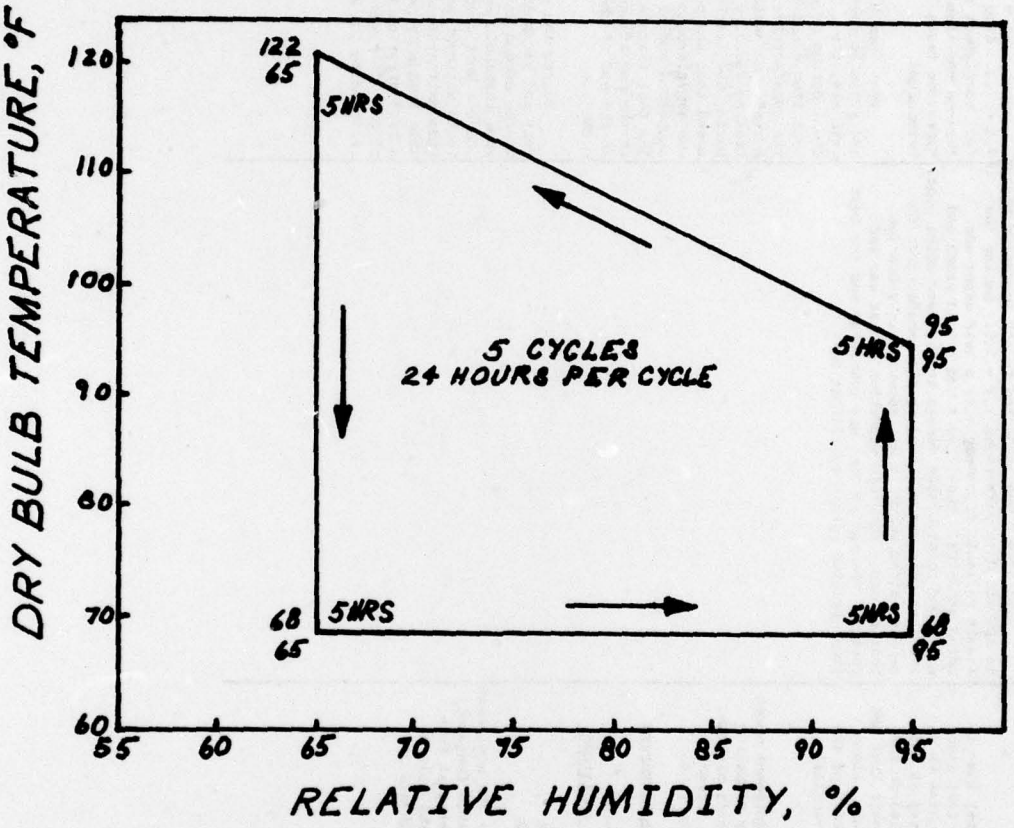

Figure 1 - TELCAM Temperature/Relative Humidity Test

SPECIFICATIONS

7. Vibration Testing

7.1 General Conditions - If the test item is designed for permanent mounting, the test item will be attached to the vibration machine in the same manner in which it will be secured on shipboard. The test item will be installed on the vibration testing machine in such manner that the direction of vibration will be, in turn, along each of the rectilinear orientation axes of the equipment as installed on shipboard vertical transverse and fore or aft.

7.2 Exploratory Vibration - The equipment under test will be subjected to exploratory vibration for approximately 15 seconds (15 seconds minimum, 60 seconds maximum) at each discrete integral frequency from 4 to 60 Hz, as given in Table 1.

TABLE 1 - EXPLORATORY VIBRATION REQUIREMENTS

Frequency (Hz)	Vibration Level (Inch Double Amplitude)
4 to 17	0.010±0.001
18 to 30	0.005±0.0005
31 to 60	0.002±0.0002

7.3 Variable Frequency Vibration - The equipment under test will be subjected to variable frequency vibration testing at each discrete integral frequency from 4 to 60 Hz. Each frequency will be maintained for 5 minutes. The test levels are given in Table 2.

TEST RESULTS

TEST ITEM A

Test item A was subjected to the vibration tests as specified in paragraphs 7.1 - 7.5. During the X-axis variable frequency test a hard error was noted at 25 Hz. Test item A had a head crash and sustained considerable damage to the read-write head. The test unit was returned to the manufacturer for repair, after which it was returned to vibration testing and a complete vibration retest was performed. The entire test was completed and the test item operated within specifications.

TEST ITEM B

Test item B was subjected to vibration tests 7.1 - 7.3. This item was not subjected to the full complement of vibration tests (7.1 - 7.5) because the item failed numerous times during vibration tests 7.1 - 7.3 and the testing was terminated.

Test item B failed the vertical exploratory and variable frequency tests because of minor problems, i.e., loose connections and adjustments. Then, during a vertical variable frequency retest, test item B had a head crash and was sent back to the manufacturer for repair. At this time it was agreed that another unit would be sent to the testing facility to resume the vibration testing. During the testing of the prior unit it had been noted that the power supply (a separate entity) was experiencing a 4.6G vibration at the unsupported end of the power supply be supported. The test fixture was modified to provide a clamp at the end of the power supply and the "G" level at the end of the power supply was reduced to 0.28G's.

During the retesting of the vertical exploratory and variable frequency tests, a malfunction in the second unit was traced to misalignment of some threshold adjustments. These were corrected and the unit completed all the vertical vibration tests whithout any failures. However, the test item malfunctioned during the longitudinal variable frequency portion of the vibration tests with a hard error at 14 Hz. At this time the testing of this item was terminated and the item was returned to the manufacturer.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B

7.3 Variable Frequency Vibration (Continued)

TABLE 2 - VARIABLE FREQUENCY VIBRATION REQUIREMENTS

Frequency (Hz)	Vibrational Level (Inch Double Amplitude)
4 to 10	0.060±0.006
11 to 17	0.020±0.002
18 to 30	0.006±0.0006
31 to 60	0.002±0.0002

7.4 Endurance Vibration - The equipment under test will be subjected to endurance vibration for 2 hours at each of the peak resonance frequencies determined during exploratory and variable vibration testing. Testing will be maintained at the peak resonant frequency, although it may shift over the two-hour period. The test level will be in accordance with Table II. If no resonance frequencies have been noted, testing will be performed at 60 Hz for 2 hours.

7.5 Shipping Vibration Test - The test item will be installed in its normal shipping configuration and packaged as if for shipment. The packaged item will be mounted in the vertical direction on the vibrator. Cycling will be performed at a sweep rate of 1 octave per minute from 5 to 200 to 5 Hz for 2 hours. The test levels are given in Table 3.

TABLE 3 - SHIPPING VIBRATION REQUIREMENTS

Frequency (Hz)	Vibration Level
5 to 6.2	0.75 inch Double Amplitude
6.2 to 200	±1.5g

Testing will be performed along each of the three orthogonal test axes.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
8. Airborne and Structureborne Noise - Measurements will be made of the test item to determine whether it meets the requirements of MIL-STD-740B[8] for grade B, type 3 equipment. Reference paragraphs 5.2 and 5.3 for test procedures and acceptance criteria.	Test item A was subjected to the airborne and structureborne noise tests in accordance with paragraph 8. The unit airborne noise was within specification. However, unit structureborne noise levels were observed which were 0.5 dB to 1.0 dB above MIL-STD-740B[8] specifications. However, levels of this magnitude fall within test equipment accuracy. All other levels were below specification requirements.	Test item B was subjected to only the structureborne noise test specification of MIL-STD-740B.[8] The test item structureborne noise levels were within specification.
9. Inclination 9.1 The test item, while operating, will be subjected to inclinations of 15° either side of vertical at any rate between 0.8 and 0.12 Hz for 30 minutes per orientation. The test item will be checked for error-free operation during this test. 9.2 The test item, while in a non-operating mode, will be subjected to an inclination of 45° either side of vertical at any rate between 0.08 and 0.12 Hz for 30 minutes per orientation. The test item will be checked for error-free operation no later than 30 minutes after inclination motions are returned to 15° either side of vertical at any rate between 0.08 and 0.12 Hz.	Test item A was subjected to the inclination test in accordance with paragraphs 9.1 and 9.2. No discrepancies were noted during testing. The test item met the specified requirements.	Test item B was subjected to the inclination test 9.2 but not to test 9.1. No discrepancies were noted during the test. The test item met the specification of inclination test 9.2.
10. Shock 10.1 The test item will be mounted on the appropriate test fixture and instrumented with a monitoring accelerometer. The equipment will not be energized during testing.	Test item A was subjected to the shock tests of paragraphs 10.1 and 10.2. No discrepancies were noted during testing. After these shock tests the test item operated satisfactorily.	The shock test were not performed on test item B.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
10. Shock (Continued) 10.2 The test item will be subjected to three half-sine shock pulses in the direction of each of the three orthogonal test axes. Each shock pulse will have an amplitude of 10±1 g's and a total duration of 20±2 milliseconds. 11. Box Drop - The testing will be performed in accordance with FED-STD-101,[9] methods 5007, 5008, 5018, and 5023, as modified by MIL-P-116G.[10] The equipment under test will be subjected to the free fall drop test or the rotational drop tests and to the impact test. The equipment will be installed in its normal shipping configuration and packaged as if for shipment. Large containers will be considered as those which measure more than 60 inches on any edge or diameter, or those which, when loaded, have gross weights in excess of 200 pounds. Small containers will be considered as those which measure 60 inches or less on any edge or diameter, and which, when loaded, have gross weights of 200 pounds or less. 11.1 Free-fall Drop (Small Containers Only) - The packaged item will be subjected to a free fall drop onto each of its eight corners and each of its six faces. The test item will be dropped onto a concrete surface. The box drop heights are given in Table 4.	Discrepancies noted during testing of test item A are given in the following tables. TABLE 8 - FACE DROP TEST RESULTS Face — Results 1 (-Z) — No Anomalies 2 (+Z) — No Anomalies 3 (-X) — No Anomalies 4 (+X) — No Anomalies 5 (-Y) — No Anomalies 6 (+Y) — No Anomalies TABLE 9 - CORNER DROP TEST RESULTS Corner — Results 1 — No Anomalies 2 — No Anomalies 3 — Slight Crush 4 — Slight Crush 5 — Cardboard Split 6 — Tape Split 7 — Tape Split 8 — Splitting along edge of Carton	Test item B was not subjected to box drop tests (11.1-11.3).

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
11. Box Drop (Continued) TABLE 4 - FREE-FALL DROP REQUIREMENTS Gross Weight (Pounds) / Longest Dimension (Inches) / Drop Height (Inches) 0 - 50 / 36 / 22 51 - 100 / 48 / 16 101 - 150 / 60 / 14 151 - 200 / 60 / 12 11.2 Rotational Drop (Large Containers Only) 11.2.1 Edgewise Drop - The packaged item will be placed on its bottom with one end supported on a sill nominally 6 inches high. The unsupported end of the container will be raised to the height given in Table 5 and allowed to drop freely onto a concrete surface. Two drops on each end will be performed. TABLE 5 - EDGEWISE DROP REQUIREMENTS Gross Weight (Pounds) / Drop Height (Inches) Up to 250 / 30 251 - 500 / 24 501 - 1000 / 18 Over 1000 / 12 11.2.2 Cornerwise Drop - The packaged item will be placed on its bottom on a concrete surface. The corners at one end of the container will be supported by blocks nominally 6 and 12 inches high. The opposite end of the container will be raised to the height given in Table 6 and allowed to drop freely. Two drops on each of two diagonally	Physical inspection of test item A revealed damage to the backplane of the unit and to switch S2. Damage was limited to areas close to corner number 8. The item operated within specification after testing.	

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B

11. Box Drop (Continued)

opposite corners of the bottom will be performed.

TABLE 6 - CORNERWISE DROP REQUIREMENTS

Gross Weight (Pounds)	Drop Height (Inches)
Up to 250	30
251 - 500	24
501 - 1000	18
Over 1000	12

11.3 Impact (Pendulum-Impact) (Large Containers Only) - The packaged item will be placed on the platform of the pendulum-impact tester. The surface to be impacted will extend beyond the platform so that it just touches the vertical surface of the bumper. The platform will be pulled back so that the center of gravity of the test item is raised to the height shown in Table 7 and then released to swing freely so that the surface of the container impacts against the bumper.

TABLE 7 - IMPACT-PENDULUM REQUIREMENTS

Gross Weight (Pounds)	Pendulum Impact Height (Inches)
Up to 250	14
251 - 500	11
501 - 1000	8
Over 1000	5

The impact test will be performed once on each of two opposite ends.

APPENDIX
ENVIRONMENTAL SPECIFICATIONS AND TEST RESULTS

SPECIFICATIONS	TEST RESULTS	
	TEST ITEM A	TEST ITEM B
12. Operational Test Procedure 12.1 The disk memory will be checked for 35 minutes (approximately 1.0×10^{10} bits) with a test set each time inspection is required. If a fault is detected, the test set will be reset, then re-started. If the fault is transient, it will be considered a soft error. If the fault recurs after reset and restart of the test sequence, the test sequence will be repeated five times to verify the existence of a hard error. 12.2 The test set will be operated for a total of 5 hours at each environmental condition of the temperature/relative humidity test. No data will be taken during transition from one environmental condition to another. Any faults will be checked to determine whether they are soft or hard errors.		

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